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ZnSe scintillating bolometer with ionization readout - a new approach for particle discrimination technique

The present report relate to results on the development of ionization read-out on ZnSe crystals, as scintillating bolometer dedicated for search of neutrinoless double beta decay of ^{82}Se isotope within LUCIFER project. This work aimed on development of triple read-out (heat channel, light channel and ionization channel) detector which, as we expect, will allow getting more information about interacting particle (in compare of scintillation bolometer) and helps to drastically reduce the background to very low level. For appropriate work of ionization read-out channel in a wide band gap semiconductor material ZnSe (band gap is ~2.81 eV at room temperature) it is necessary to figure out the basic possibility of this detector creation. The principle of operation of a semiconductor detector is the following: if an ionizing particle penetrates the detector it produces electron-hole pairs along its track, the number being proportional to the energy loss. An externally applied electric field separates the pairs before they recombine; electrons drift towards the anode, holes to the cathode; the charge is collected by the electrodes (charge collection). The collected charge produces a current pulse on the electrode, whose integral equals the total charge generated by the incident particle, i.e. is a measure of the deposited energy. The readout goes through a charge-sensitive preamplifier, followed by a shaping amplifier. According to the published data the electron mobility in ZnSe at room temperature (T=300 K) is about 530 cm^2/ V×s with a concentration of free carriers $n_0 \sim 10^{17\text{-}18}$ cm^{-3}. Going down to the lower temperature drastically increases the electron mobility up to 12 000 cm^2/ V×s at T=60 K. Relying on these data we expect to collect even tiny charges induced in ZnSe by double beta decay event. But still there is no data yet on fundamental electrical properties for ZnSe under very low temperatures were scintillation bolometer operates (about a few mK). Besides, there is a big difference between ideal crystal (for which we can approximately estimate all necessary electrical parameters), and real crystal for which the only way to determine the mentioned above parameters is to make an experiment. To be consistent, as first stage, the optical and scintillation characteristics of different ZnSe crystals have been studied. The results on the tests of ZnSe semiconductor detectors at room temperature and under low temperature are presented.

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